REMARKS

Claims 1-20 are pending in the Application. Claims 6-7, 12 and 14-17 are canceled with this Amendment. Claim1 has been amended to recite that the method provides a metal seed layer substantially free of discontinuities and substantially fills the apertures with copper. Support for this is found in the Specification at page 8, lines 11-14. Claim 11 has been amended similarly to claim 1. Claims 5, 8-10 and 13 have been amended so that they now depend from claim 18. No new matter is added with this Amendment.

Applicants' invention is directed, inter alia, to a method of both providing a seed layer substantially free of discontinuities and filling apertures with copper by contacting a substrate having $\leq 1\mu m$ apertures and a discontinuous seed layer with an alkaline copper electroplating bath comprising copper pyrophosphate. Sufficient current density is then applied to provide a metal seed layer substantially free of discontinuities and to substantially fill the apertures with copper.

Claims 1-11, 14, 15 and 18-20 have been rejected under 35 USC § 103(a) as being unpatentable over Chen (US 6,197,181) in view of Mahapatra et al. (US 6,301,399). Applicants respectfully traverse.

Chen discloses enhancing an ultra-thin seed layer by electroplating using an alkaline copper bath. The only alkaline copper bath disclosed in Chen is a copper sulfate bath. See column 5, lines 36-39 and Example 1. Chen states at column 4, lines 50-52, that ultra-thin seed layers can be used only if they are combined with a *subsequent* seed layer enhancement technique. Chen further states at column 4, lines 52-60:

> To this end, the semiconductor workpiece is subject to a subsequent process step in which a further amount of copper **18** is applied to the ultra-thin seed layer to thereby enhance the seed layer. A seed layer enhanced by the additional deposition of copper is illustrated in FIG. 2C. As shown in FIG. 2C, the void or non-continuous regions **20** of FIG. 2B have been filled thereby leaving substantially all of the barrier layer **10** covered with copper.

It is quite clear from Figs. 2C and 2D of Chen that an enhanced seed layer **22** is provided followed by a *subsequently* deposited metallization layer (see Fig. 2D). This is further supported by Chen at column 3, lines 61-65, which states.

> The enhanced copper seed layer provides an excellent conformal copper coating that allows trenches and vias to be *subsequently* filled with a copper layer having good uniformity using electrochemical deposition techniques. [Emphasis added.]

Chen further states at column 6, lines 64-66, that "[w]ith the seed layer enhanced in the foregoing manner, it is suitable for *subsequent* electrochemical copper deposition." [Emphasis added.] Thus it is clear to one skilled in the art that Chen teaches enhancing an ultra-thin seed layer using a first electroplating bath, and then *subsequently* filling the apertures (vias and trenches) using a second electroplating bath.

Applicants have surprisingly found that using a copper pyrophosphate electroplating bath provides enhanced seed layers *and* substantially fills apertures using a single electroplating bath. Nothing in Chen teaches or suggests a copper pyrophosphate electroplating bath. Further, Chen neither teaches nor suggests a single bath to both enhance a seed layer and substantially fill the apertures.

The Mahapatra patent does not fill the deficiencies of Chen. Mahapatra is relied upon for the teaching of the components of a copper pyrophospate bath. See the official Action at page 3. However, this teaching still does not suggest contacting a discontinuous seed layer with a copper electroplating bath. The Mahapatra patent fails to disclose discontinuous seed layers, and, in fact, fails to recognize the problems associated with discontinuous metal seed layers. Such discontinuous metal seed layers are particularly problematic on substrates having one or more ≤ 1 μm apertures. This patent neither discloses nor suggests substrates having ≤ 1 μm sized apertures. In fact, Mahapatra fails to disclose or suggest substrates having apertures at all. Mahapatra fails to disclose or suggest integrated circuit devices.

There is no motivation in this combination of references to use a single copper pyrophosphate electroplating bath to both repair a discontinuous seed layer and substantially fill apertures in a substrate. Separate steps of depositing second seed layers and separate steps of repairing a seed layer in one copper plating bath and then filling apertures in a second copper plating bath, such as taught by Chen, can be avoided by the present invention. Such could not be predicted from a combination of Chen and Mahapatra. Applicants submit the Examiner has not

made out a prima facie case of obviousness and respectfully request that this rejection be withdrawn.

Claims 12 and 13 have been rejected under 35 USC § 103(a) as being unpatentable over Chen in view of Mahapatra and further in view of Tsai et al. (US 6,110,817). Applicants respectfully traverse.

Chen and Mahapatra are discussed above.

Tsai is directed to a method of preventing copper migration by filling features with a *carbon-doped copper* deposit. In order to achieve such carbon-doped copper deposit, the copper plating bath must have a certain carbon concentration. Only in this way can the purpose of Tsai, i.e. to prevent copper electromigration, be fulfilled. No other copper electroplating baths are taught or suggested by Tsai. Tsai is cited for teaching CMP. However, this reference brings nothing more. Specifically, Tsai neither teaches nor suggests using a single copper pyrophosphate electroplating bath to enhance a discontinuous seed layer and substantially fill apertures. Thus, there is nothing in Tsai that teaches or suggests Applicants' claimed invention.

There is no motivation in any of these references to combine them to repair a discontinuous copper seed layer in an aperture and deposit copper into the aperture to substantially fill the aperture using a single copper plating bath, particularly a copper pyrophosphate bath. Even if one were to combine these references, there is nothing in any of them alone or in combination that would lead one to expect that a discontinuous seed layer in an aperture can be repaired and that copper can be deposited into an aperture to substantially fill the aperture using a single copper pyrophosphate electroplating bath. In particular: 1) neither Tsai nor Mahapatra disclose or suggest seed layers having discontinuities; 2) neither Tsai nor Mahapatra recognize the problem of discontinuous seed layers; 3) Chen teaches a first alkaline copper electroplating bath to enhance ultra-thin seed layers and a *subsequent* copper electroplating bath to metallize apertures; and 4) neither Chen, Mahapatra nor Tsai, alone or in any combination, teach or suggest that an alkaline copper pyrophosphate electroplating bath can both repair a discontinuous seed layer in an aperture and deposit copper in an aperture to substantially fill the aperture.

Absent Applicants' own teaching in the Specification, there is nothing in any reference alone or in combination that would motivate one skilled in the art to combine these references. Even if one were to combine these references, there is nothing in this combination that teaches or suggests that a single alkaline copper pyrophosphate electroplating bath can both repair a discontinuous seed layer in an aperture and deposit copper in an aperture to substantially fill the aperture. Applicants submit that the Examiner has not made out a prima facie case of obviousness and respectfully request that this rejection be withdrawn.

Favorable reconsideration in the form of a notice of allowance is respectfully requested.

Respectfully submitted,

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